MPI Fringe Tracker Anomaly

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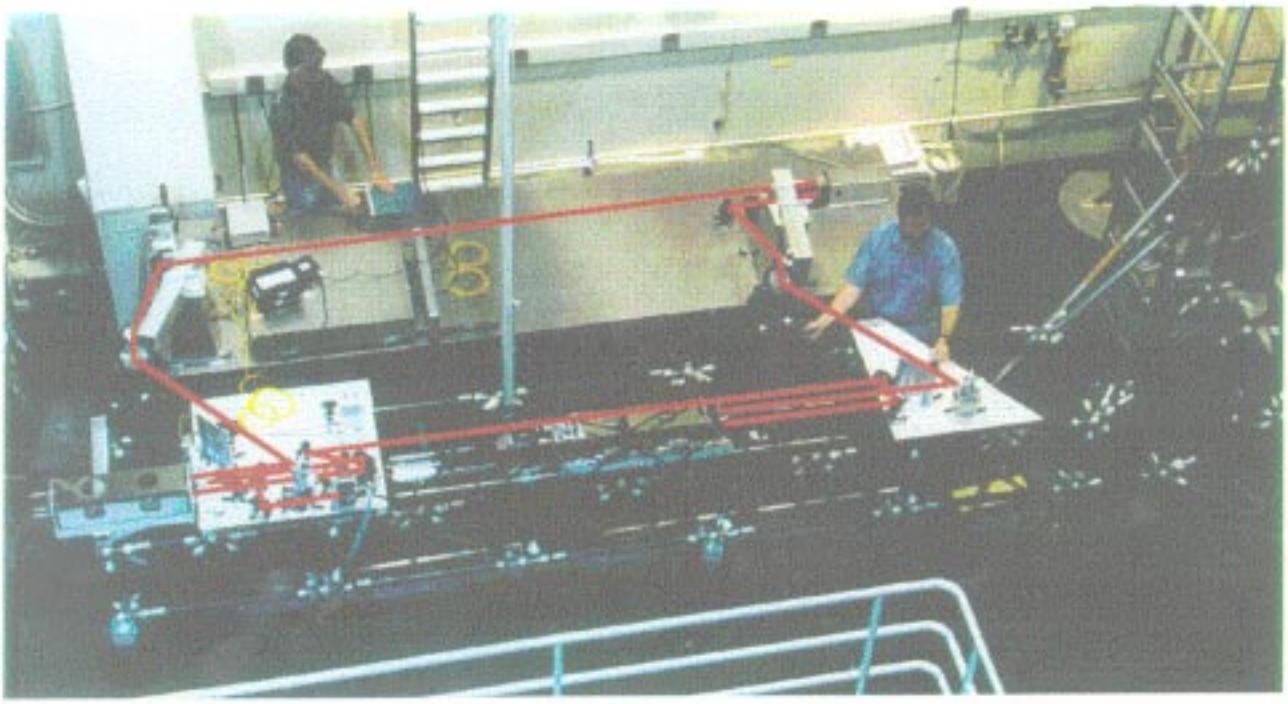
Presentation Outline

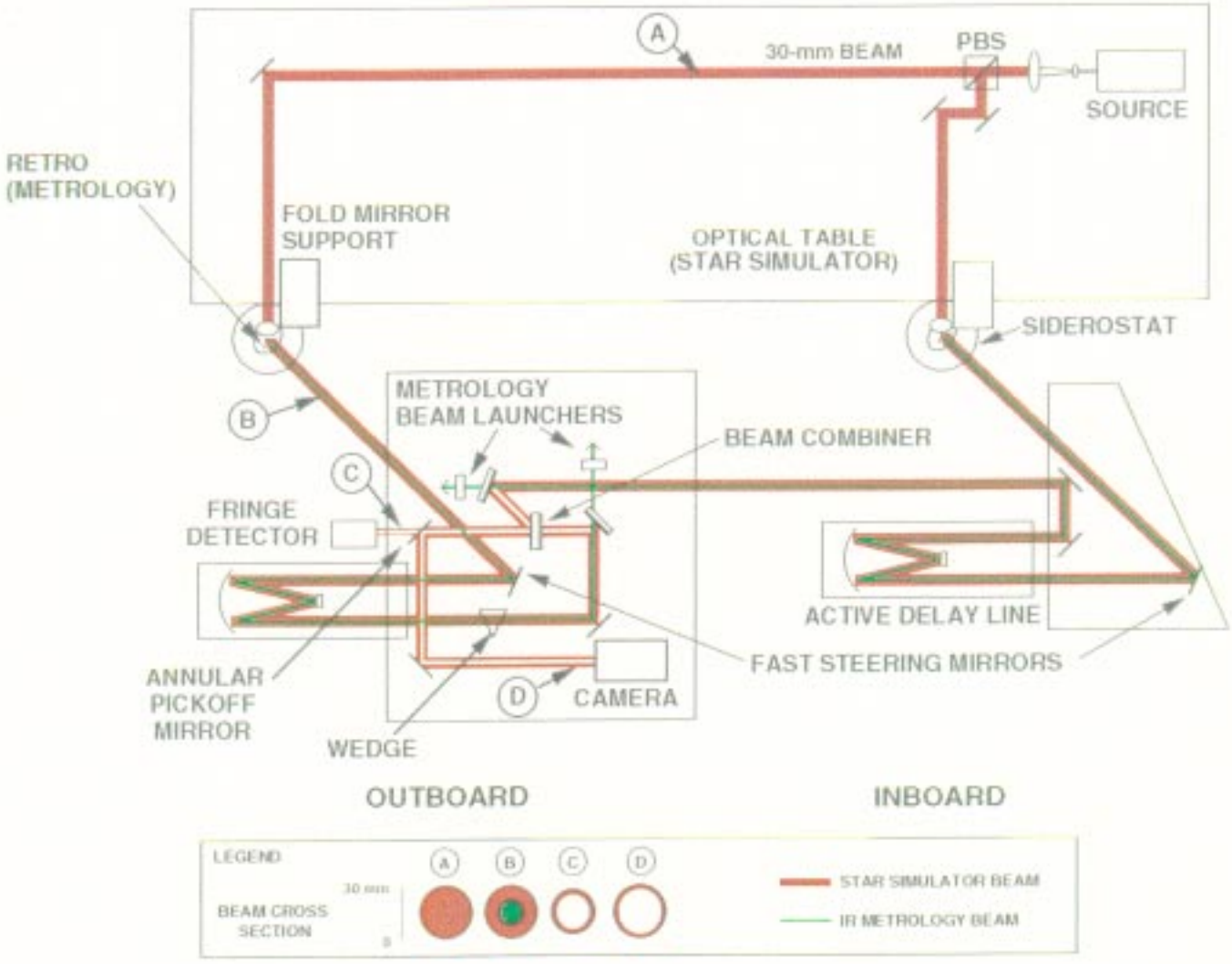
I. Fringe Tracker Description

II. Tests Performed

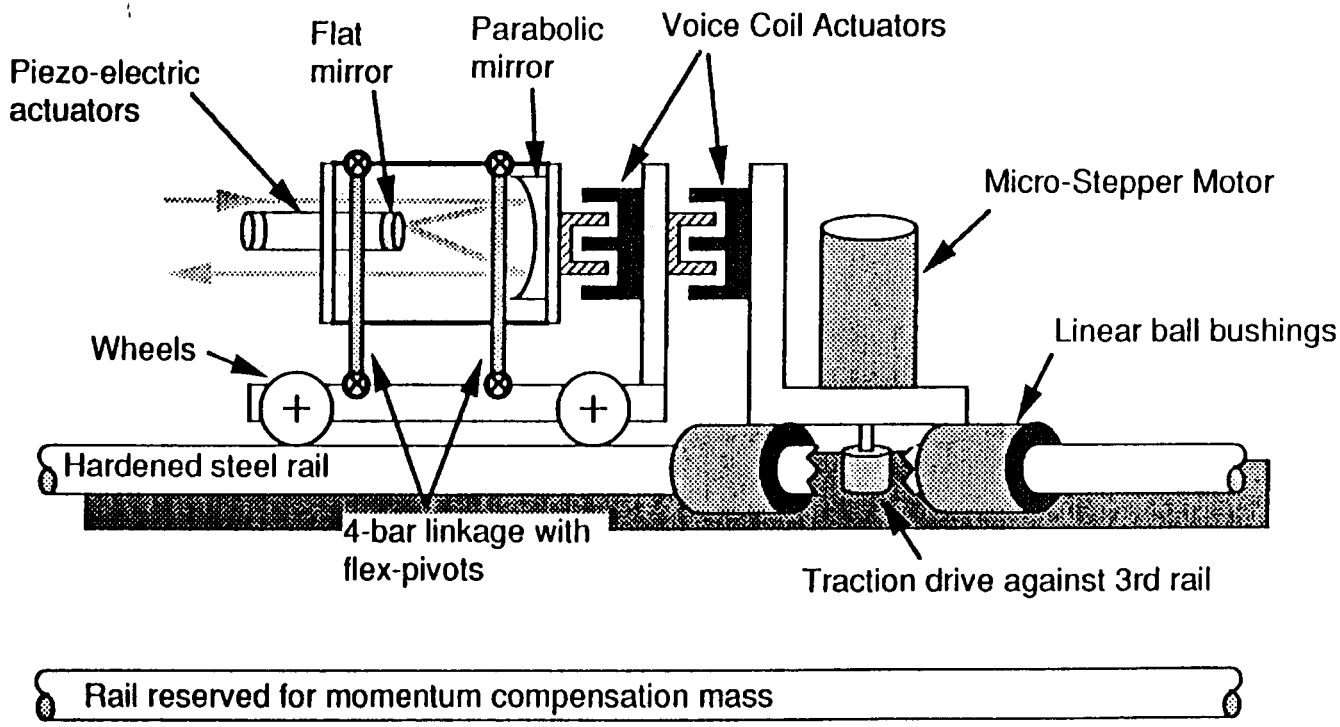
III. Solutions/Repairs

IV. Implications for SIM

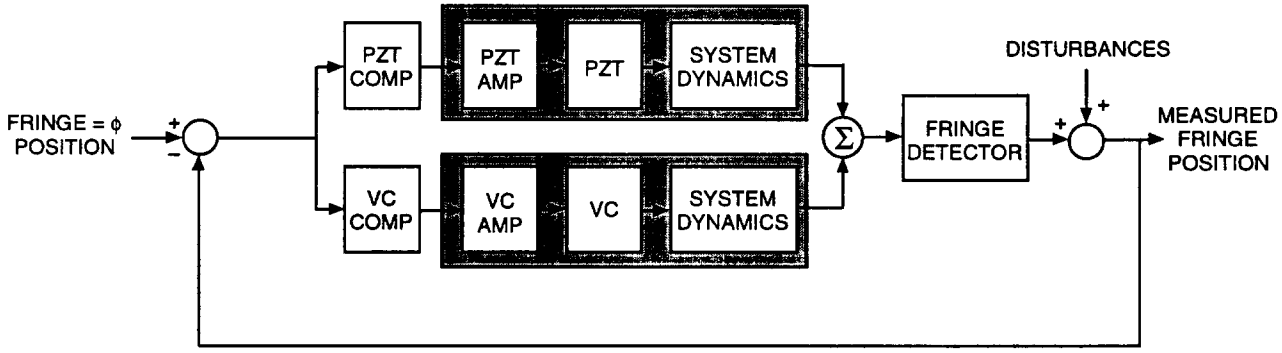


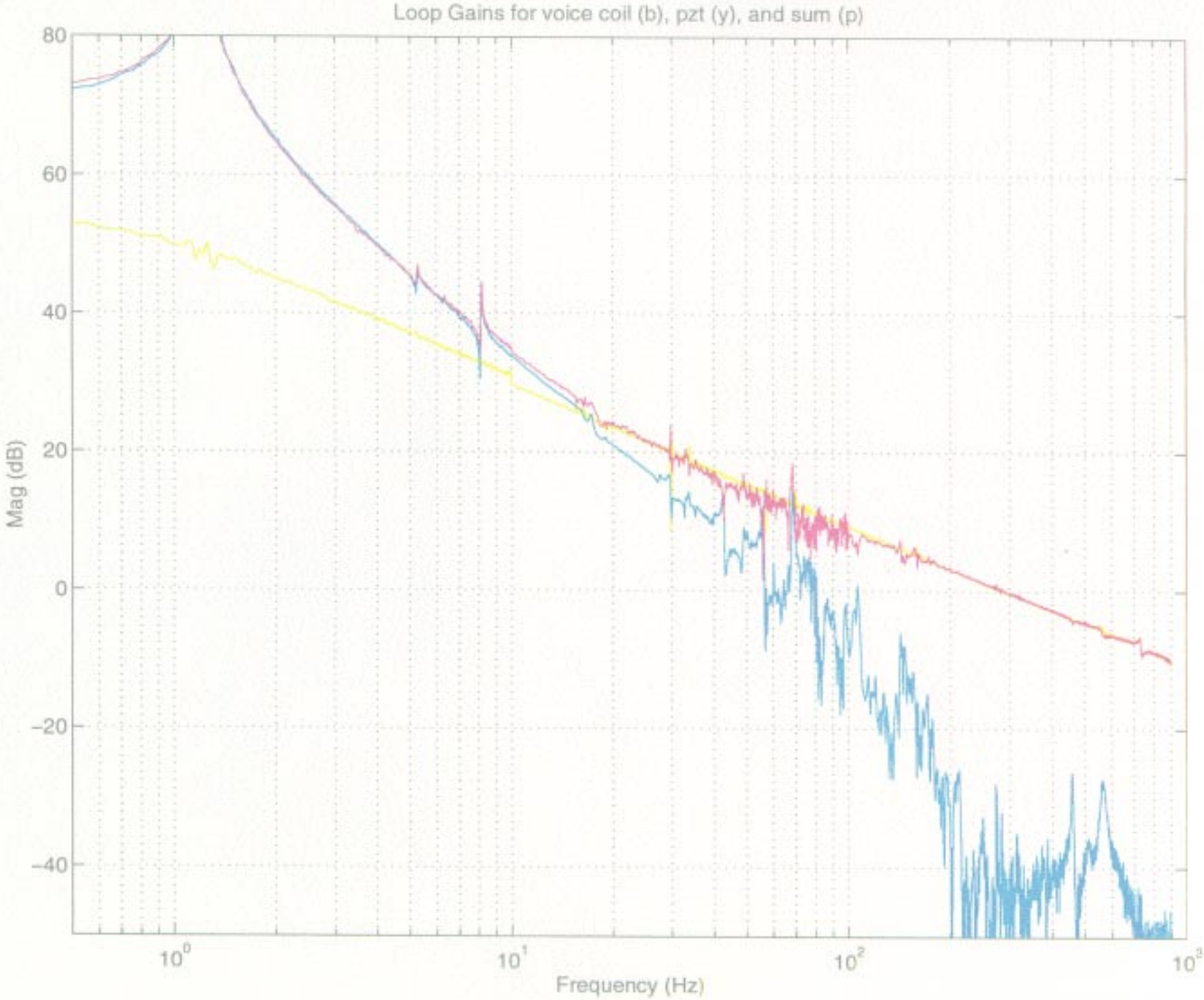

A
30-mm BEAM
PBS
SOURCE
RETRO
(METROLOGY)
FOLD MIRROR
SUPPORT
OPTICAL TABLE
(STAR SIMULATOR)
SIDEROSTAT
B
METROLOGY
BEAM LAUNCHERS
BEAM COMBINER
C
FRINGE
DETECTOR
ACTIVE DELAY LINE
FAST STEERING MIRRORS
ANNULAR
PICKOFF
MIRROR
D
CAMERA
WEDGE
OUTBOARD
INBOARD
LEGEND
A
B
C
D
30 mm
BEAM CROSS
SECTION
0
STAR SIMULATOR BEAM
IR METROLOGY BEAM

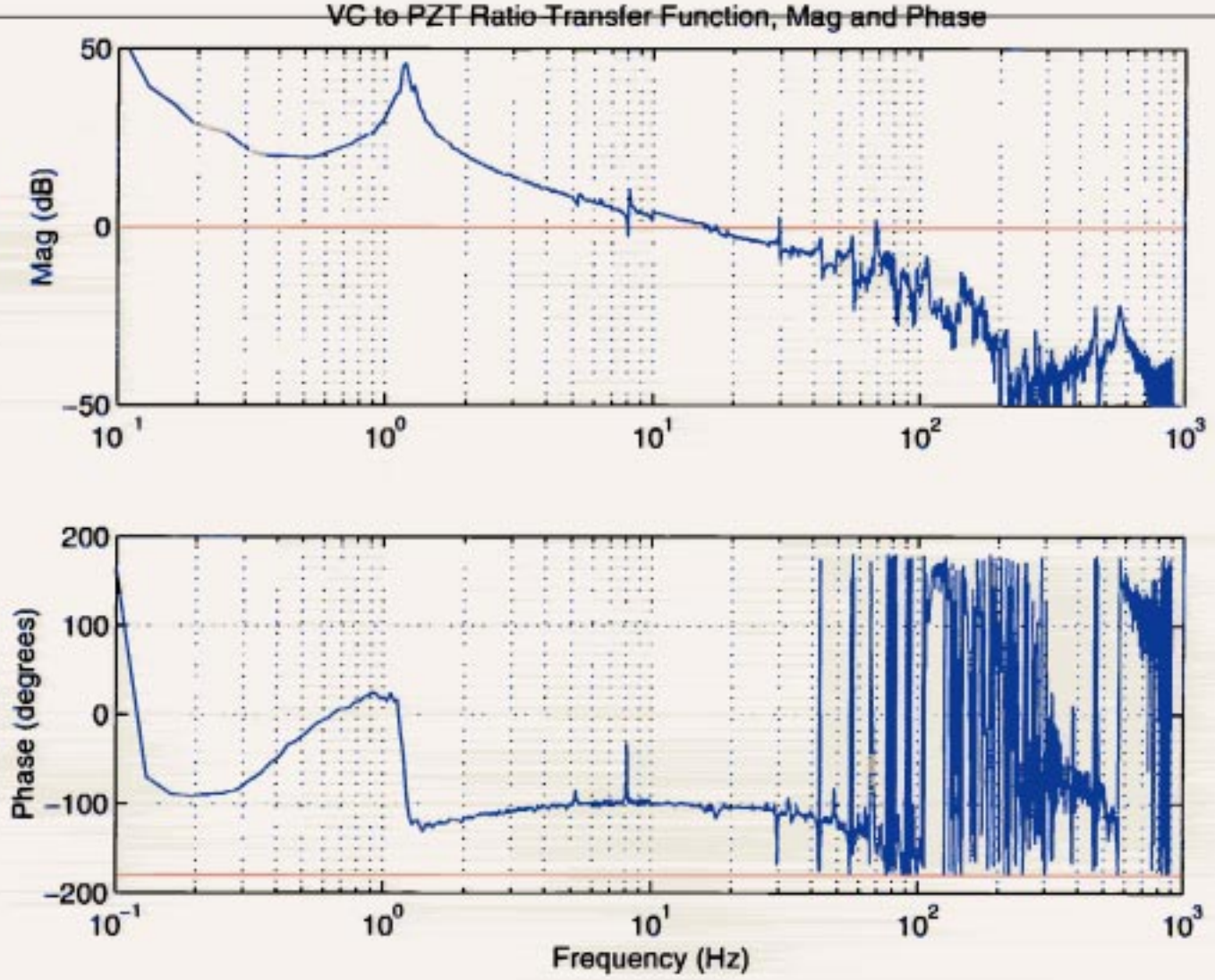
Schematic Diagram of Inherited Optical Path Delay Line Trolley



MPI TESTBED FRINGE TRACKER BLOCK DIAGRAM

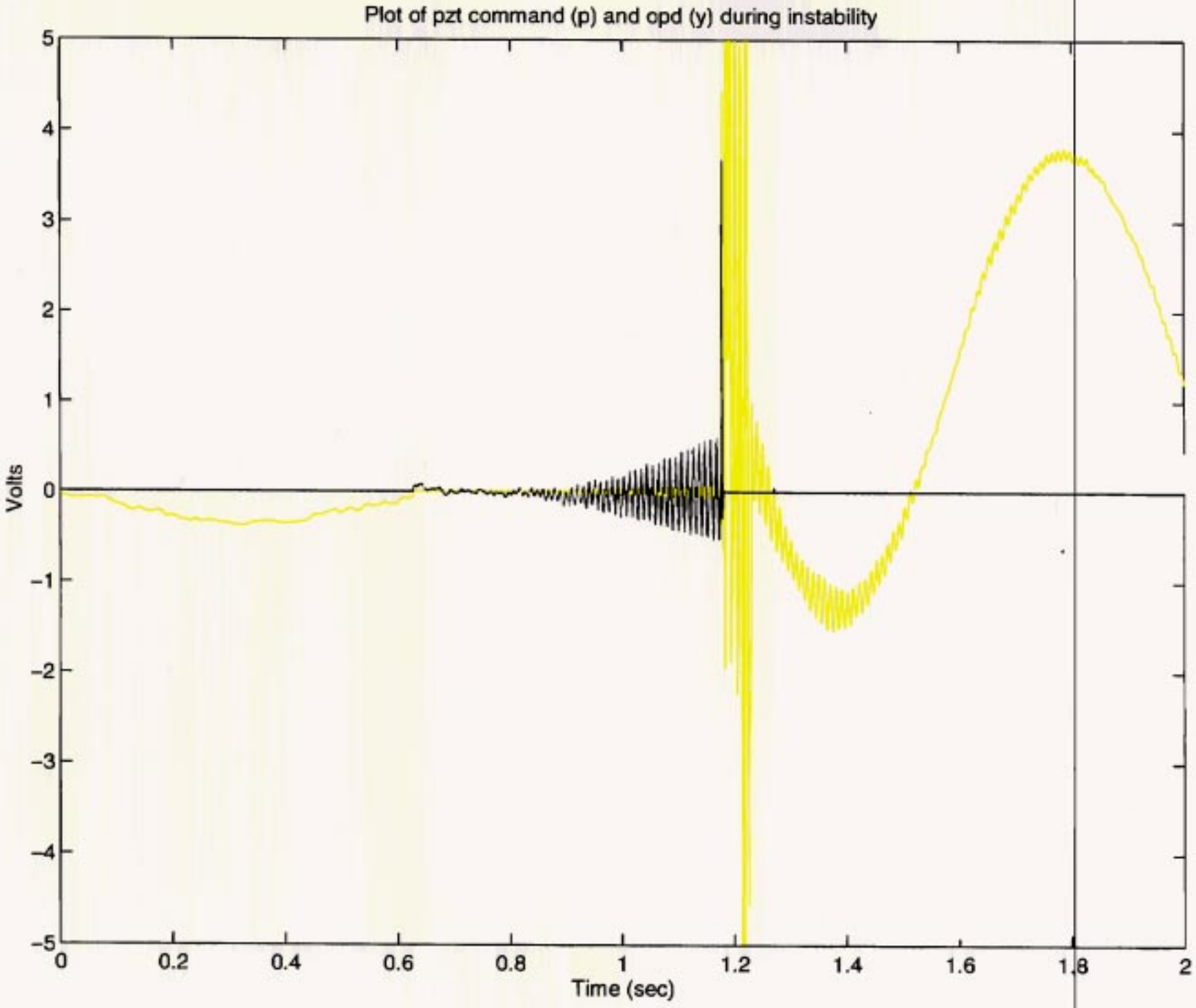


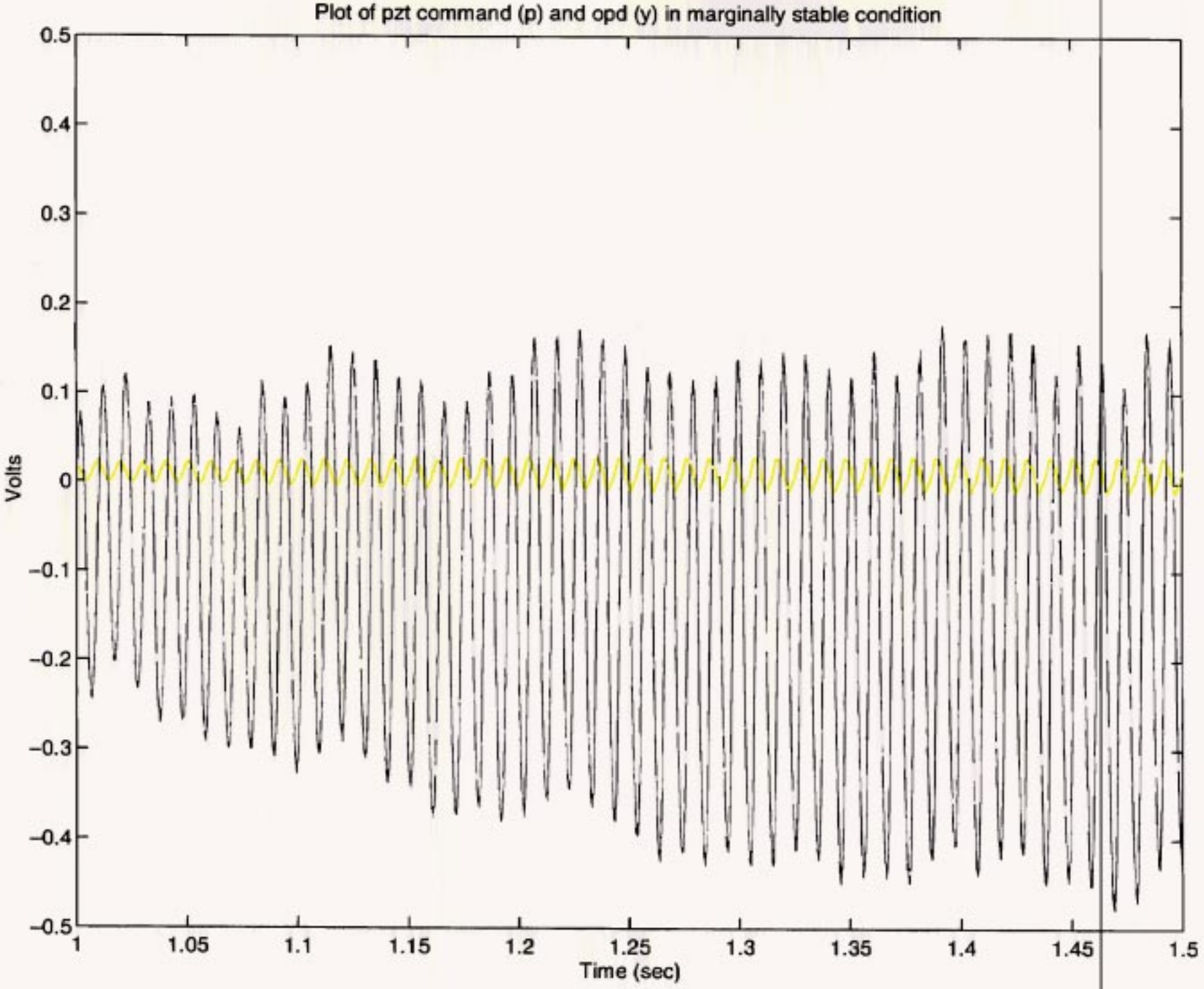

Loop Gains for voice coil (b), pzt (y), and sum (p)
80
60
40
20
0
-20
-40
Mag (dB)
10^0
10^1
10^2
10^3
Frequency (Hz)

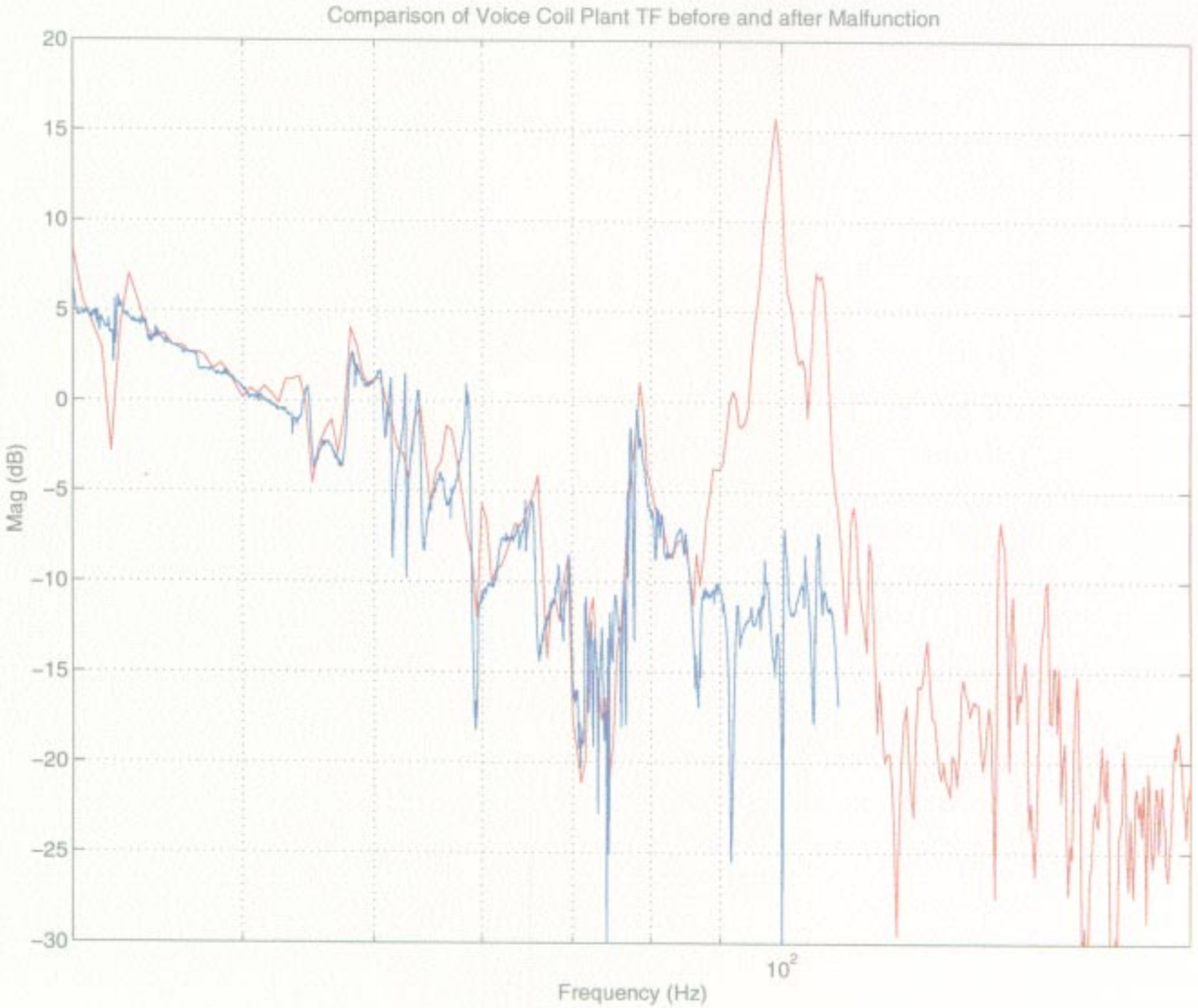

VC to PZT Ratio Transfer Function, Mag and Phase
Mag (dB)
50
0
−50
10 ¹
10⁰
10¹
10²
10³
Phase (degrees)
200
100
0
−100
−200
10⁻¹
10⁰
10¹
10²
10³
Frequency (Hz)

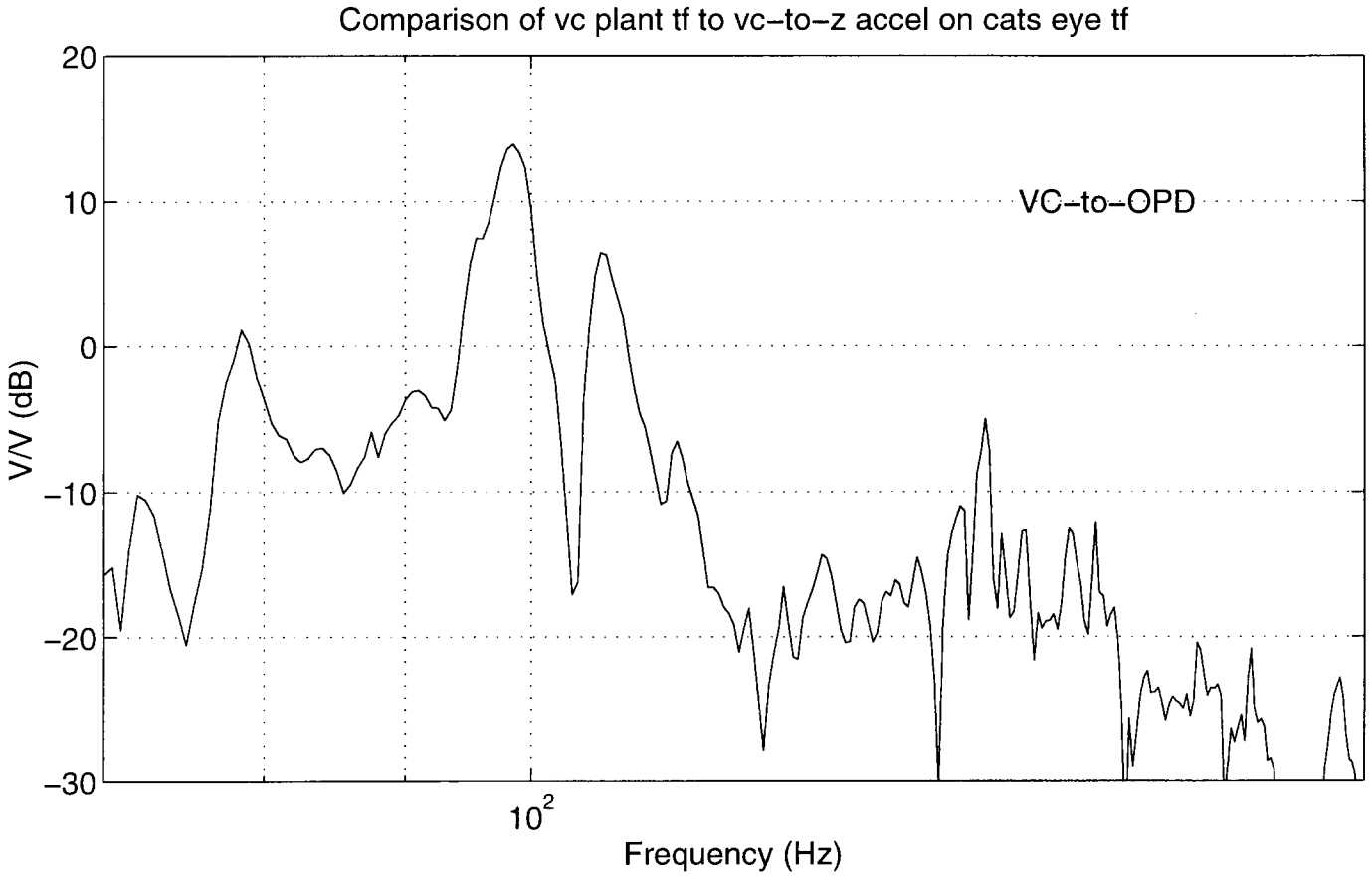
Tests Performed

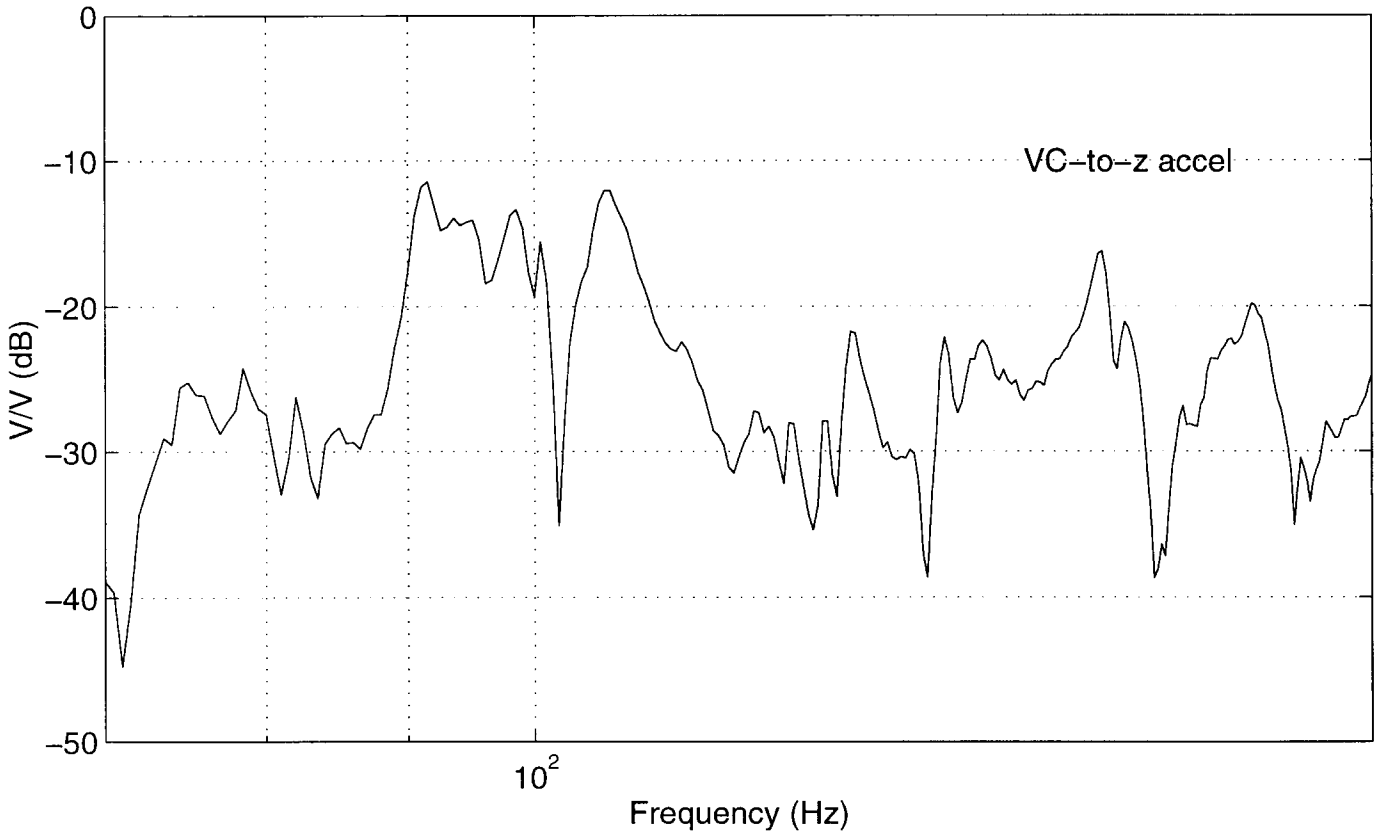
1. Time Capture of OPD and PZT command
2. Voice Coil Plant Transfer Function Measurement
3. Voice Coil-to- Accelerometer Transfer Function Measurement
4. PZT Tests
    - measure transfer function
    - rotate secondary and reactuator shafts
    - remove secondary and reactuator completely
    - replace with dummy Al shaft
    - add mass
5. Add Masses


Plot of pzt command (p) and opd (y) during instability
Volts
Time (sec)
5
4
3
2
1
0
-1
-2
-3
-4
-5
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2


Plot of pzt command (p) and opd (y) in marginally stable condition
0.5
0.4
0.3
0.2
0.1
0
−0.1
−0.2
−0.3
−0.4
−0.5
Volts
1
1.05
1.1
1.15
1.2
1.25
1.3
1.35
1.4
1.45
1.5
Time (sec)

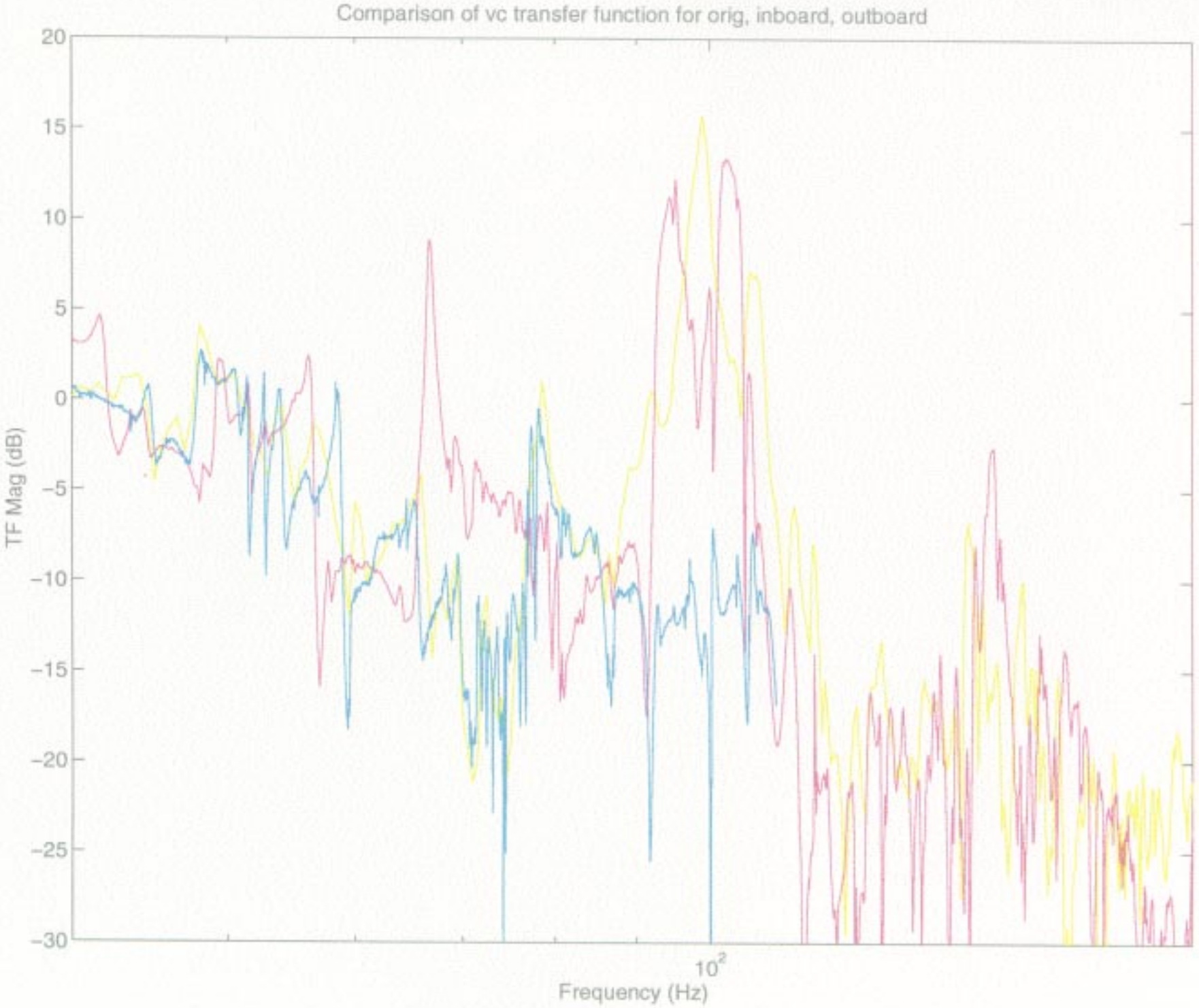

Comparison of Voice Coil Plant TF before and after Malfunction
20
15
10
5
0
−5
−10
−15
−20
−25
−30
Mag (dB)
10^2
Frequency (Hz)


Comparison of vc plant tf to vc–to–z accel on cats eye tf
20
10
0
−10
−20
−30
V/V (dB)
VC–to–OPD
10^2
Frequency (Hz)

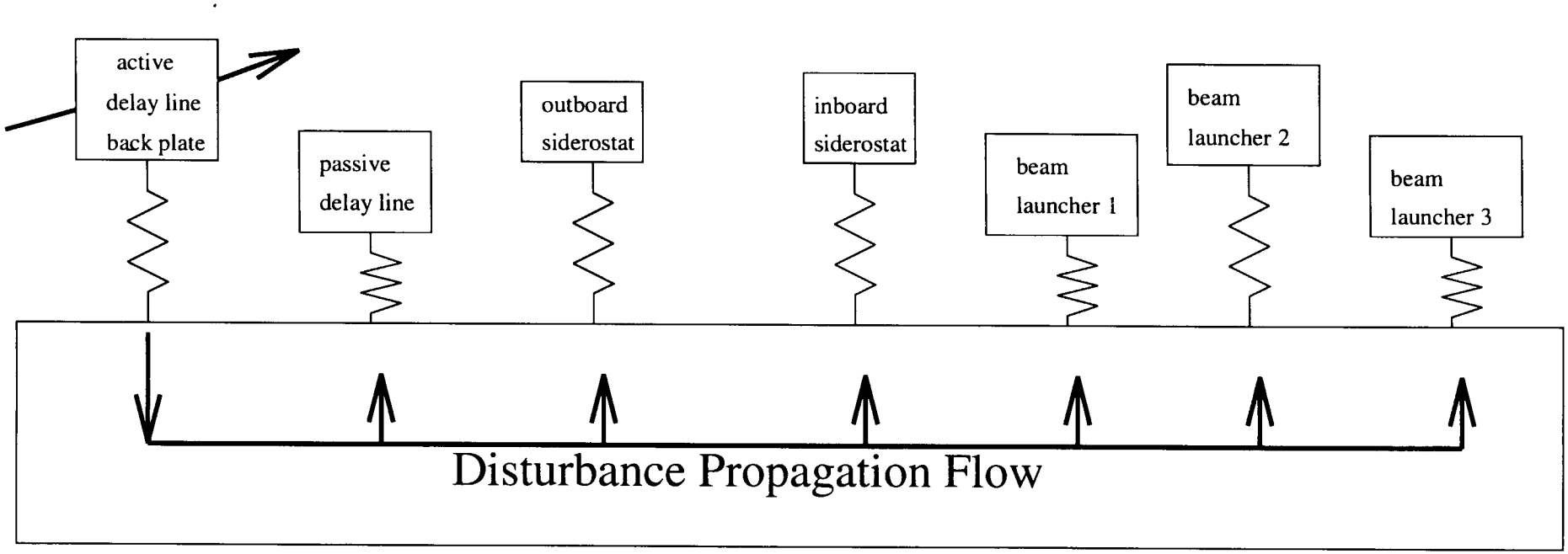

0
−10
−20
−30
−40
−50
V/V (dB)
VC–to–z accel
10^2
Frequency (Hz)

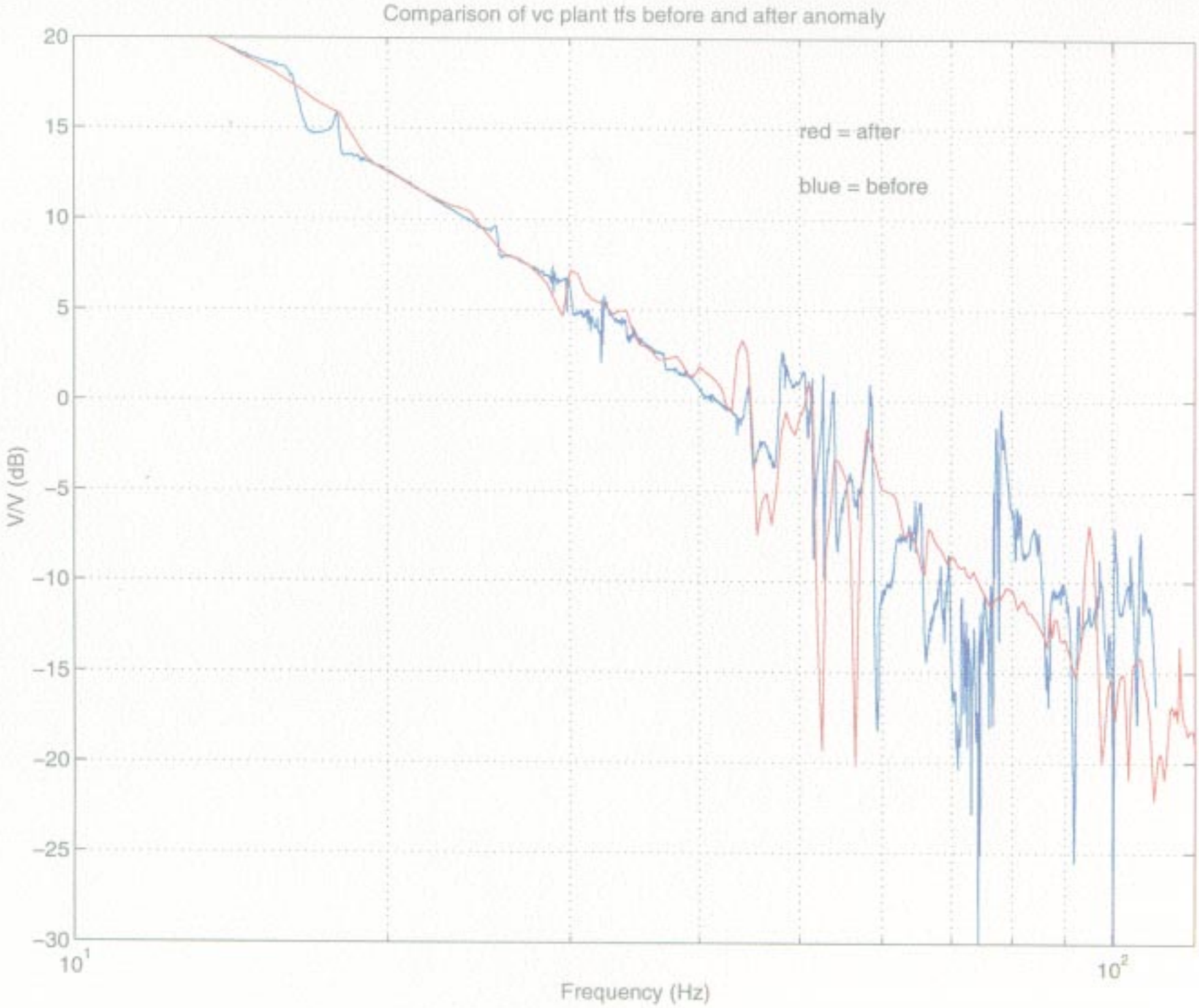
Tests Performed (continued)

6. Flexure Checkout
    - inspection
    - measure 1 Hz mode
7. Assess Voice Coil Transfer Function Linearity
8. Focus Delay Line
9. Switch Voice Coils
10. Switch Voice Coil Amps
11. Voice Coil Transfer Function at Different Cart Positions
12. Change Cart Boundary Conditions
13. 100 Hz Drive (low amplitude)
14. 100 Hz Drive (high amplitude)


Comparison of vc transfer function for orig, inboard, outboard
20
15
10
5
0
−5
−10
−15
−20
−25
−30
TF Mag (dB)
10^2
Frequency (Hz)

What Happened ?




Comparison of vc plant tfs before and after anomaly
red = after
blue = before
V/V (dB)
Frequency (Hz)
20
15
10
5
0
−5
−10
−15
−20
−25
−30
10^1
10^2

Implications for SIM

Perform on-orbit?	Tests Performed
yes	1. Time Capture of OPD and PZT command
yes	2. Voice Coil Plant Transfer Function Measurement
?	3. Voice Coil-to- Accelerometer Transfer Function Measurement
	4. PZT Tests
yes	- measure transfer function
no	- rotate secondary and reactuator shafts
no	- remove secondary and reactuator completely
no	- replace with dummy Al shaft
no	- add mass
no	5. Add Masses
	6. Flexure Checkout
no	- inspection
yes	- measure 1 Hz mode
yes	7. Assess Voice Coil Transfer Function Linearity
?	8. Focus Delay Line
no	9. Switch Voice Coils
?	10. Switch Voice Coil Amps
yes	11. Voice Coil Transfer Function at Different Cart Positions
yes	12. Change Cart Boundary Conditions
yes	13. 100 Hz Drive (low amplitude)
?	14. 100 Hz Drive (high amplitude)

Implications for SIM

Given that the anomaly occurred, what would we do about it?.....

	on ground	on orbit
fix it	- mechanically tune	- switch delay lines (need redundancy)
live with it	- no way	- redesign fringe tracker and pointing loops

Implications for SIM

How could this condition have been avoided on SIM?

1. System Level Design Issues
    - momentum compensate the voice coils
    - avoid local "mode stacking"
    - actuator isolation
2. Model Fidelity not Sufficient to Predict this Problem
    - try to identify troublesome areas and put fidelity there
3. Add Accelerometers to Sensor Suit for Problem Diagnosis
    - locate in anticipated troublesome areas
4. Suggestions for Software Fault Detection and Recovery
    - capable of reconfiguring to a more complex control configuration
    - accommodate suite of diagnostic tests
5. Include a Redundant Delay Line